Aerobic TCE degradation by willows and three root colonizing strains of B. cepacia

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Aerobic TCE degradation by willows and three root colonizing bacterial strains of *B. cepacia*

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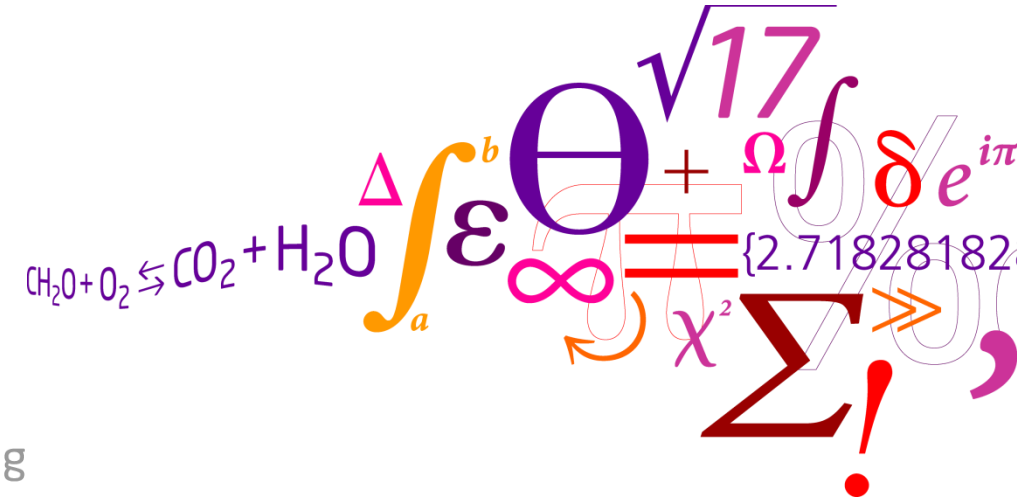
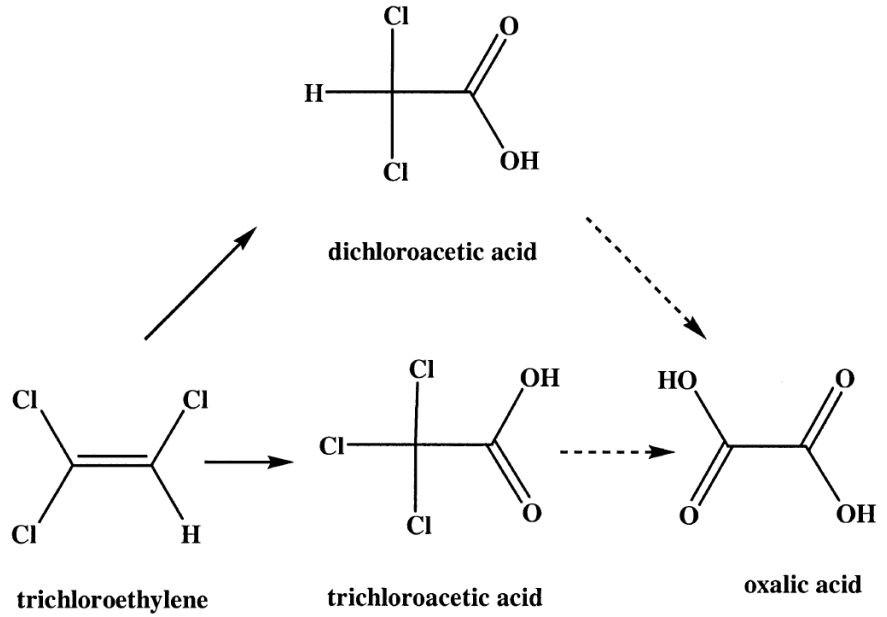


DTU Environment
Department of Environmental Engineering

Introduction

Several studies indicate aerobic **T**ri**c**hloro**e**thylene (TCE) degradation by plants.



Aerobic TCE degradation in plants (Shang et al., 2001)

Degradation pathway similar to that of mammals (monooxygenase):

TCE → **t**ri**c**hloro**a**cetic **a**cid (TCAA) and **di**chloro**a**cetic **a**cid (DCAA) → oxalic acid

But we know very little about the rates…

Test groups

Group	Description	No. of replicates
Control with Cl	Standard Hoagland nutrient solution, no TCE	5
Control no Cl	Modified Hoagland with no Cl, no TCE	5
Low exposure	Start exposure 5 mg TCE/L, no added bacteria	5
High exposure	Start exposure 20 mg TCE/L, no added bacteria	5
Dead	20 mg TCE/L with a dead willow stick, no refill, no added bacteria	4
Control	Start exposure 25 mg TCE/L, no added bacteria	6
301C	Start exposure 25 mg TCE/L, B. *cepacia* 301C	6
PRI-31	Start exposure 25 mg TCE/L, B. *cepacia* PRI-31	6
pTOM	Start exposure 25 mg TCE/L, B. *cepacia* pTOM	6
c301C	B. *cepacia* 301C, no TCE	3

Temp. ~ 20°C; Light intensity ~ 5000 lux; Humidity ~ 50%

Lab set-up

Burkholderia cepacia *(Pseudomonas cepacia)*

Gram-negative

Rod-shaped

Size: 1.6- 3.2 µm

Degradation of chlorinated compounds (TCE, 2,4,5-trichlorophenoxyacetic acid and more)

(Folsom, 1990)

Colonize plant roots

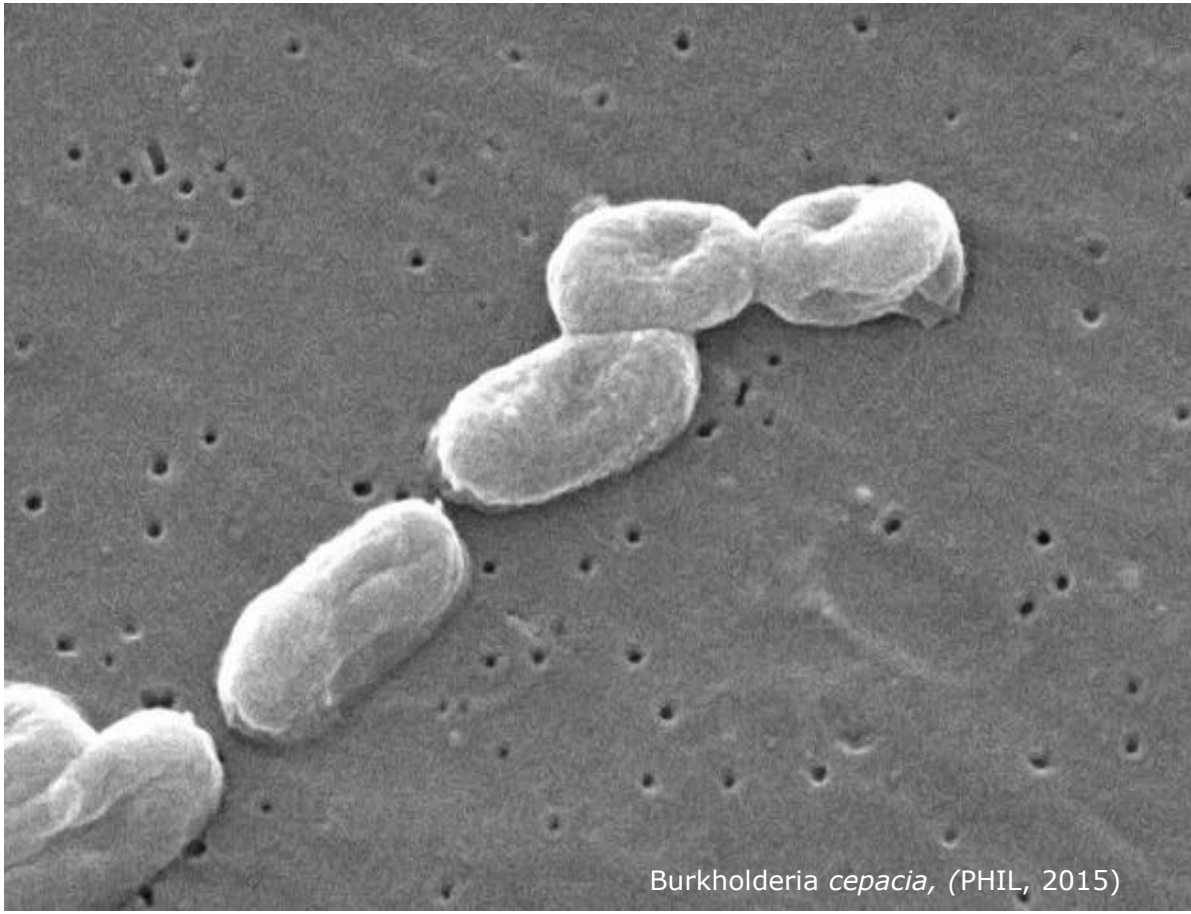
(DMI, 2015)

B. *Cepacia* strains used:

301C

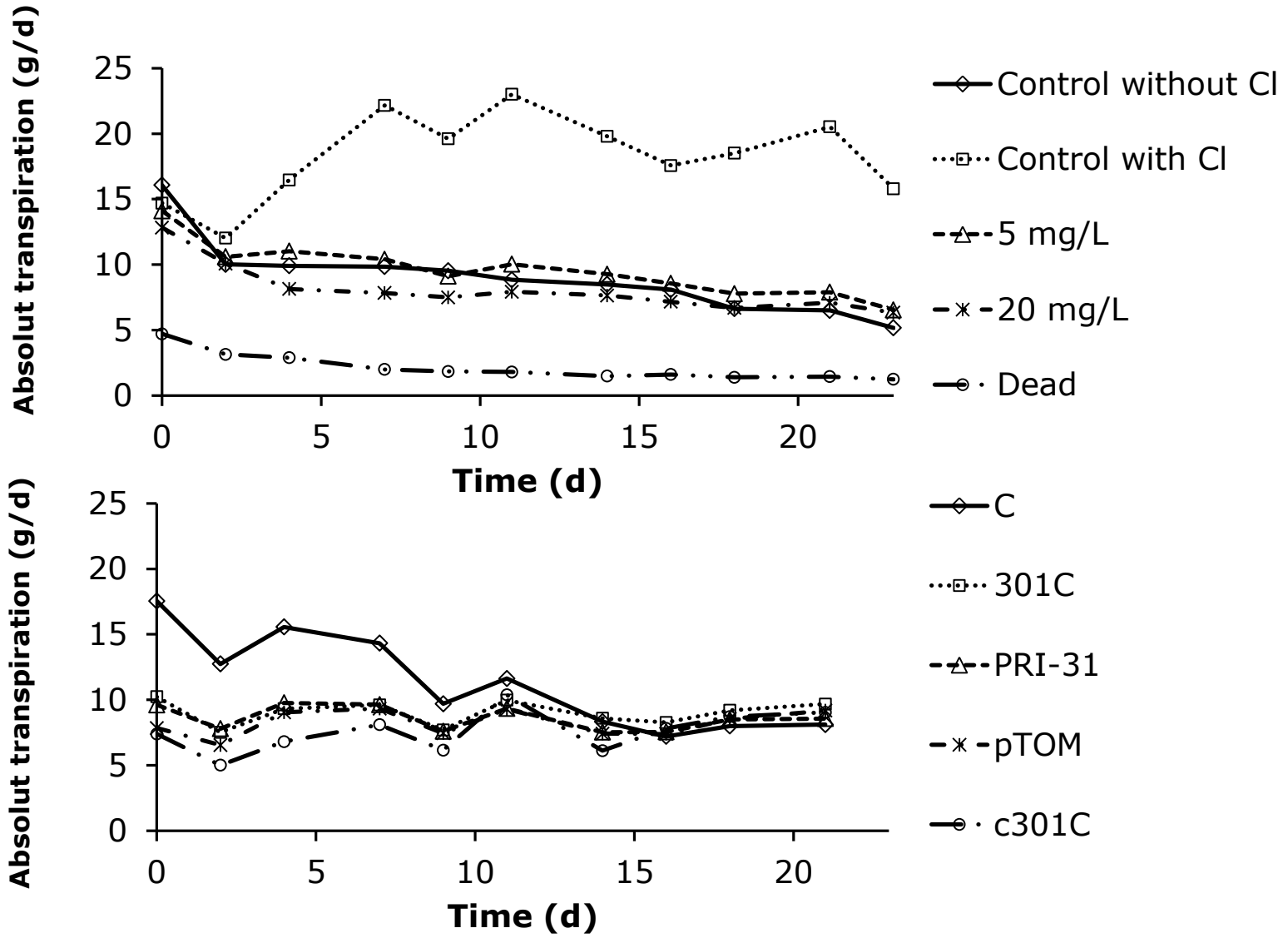
PRI-31

pTOM

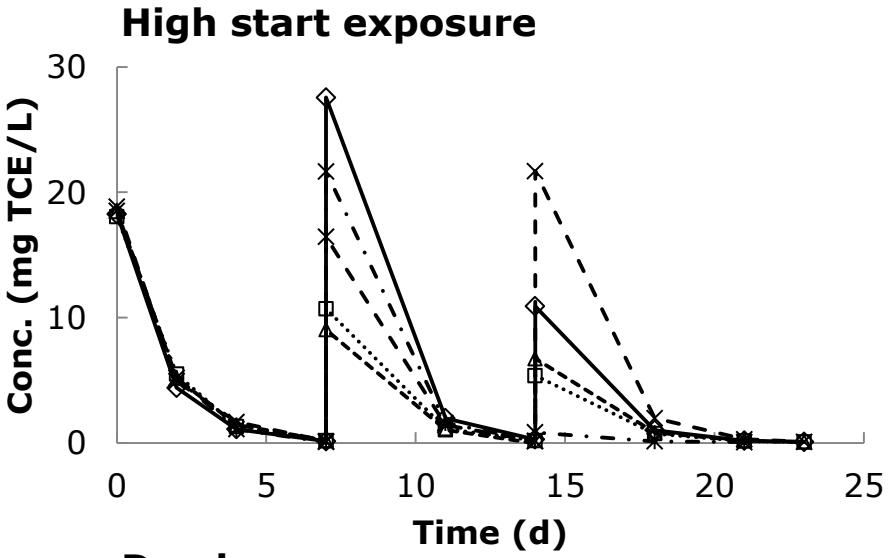


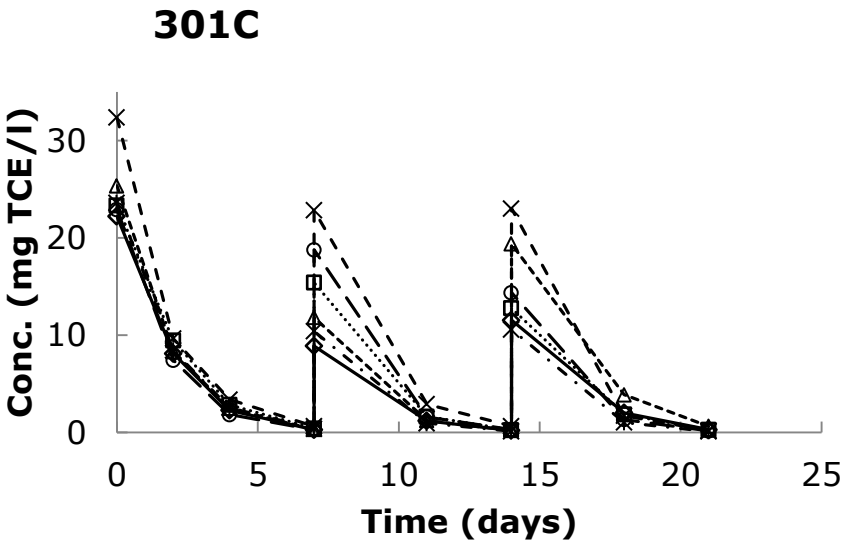
Burkholderia *cepacia, (*PHIL, 2015)

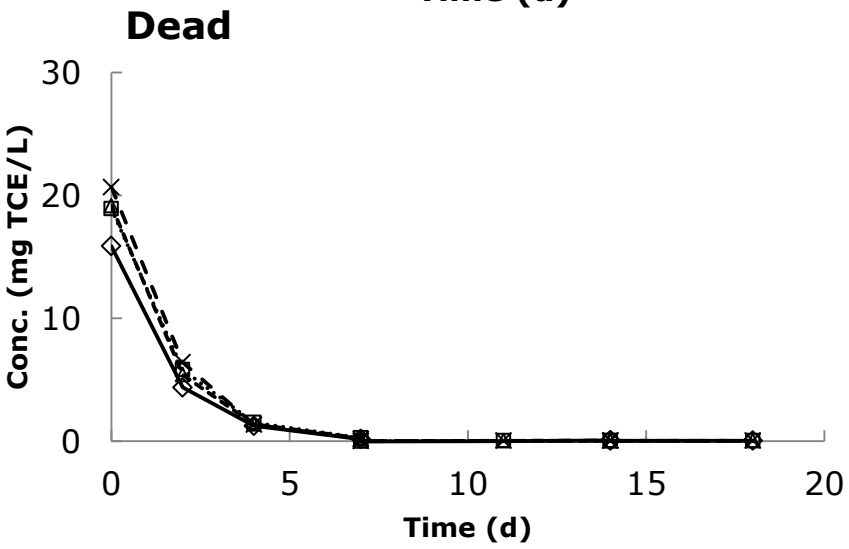
Transpiration of the willows

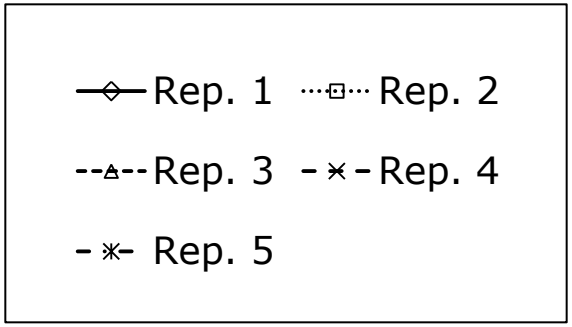


TCE in solution

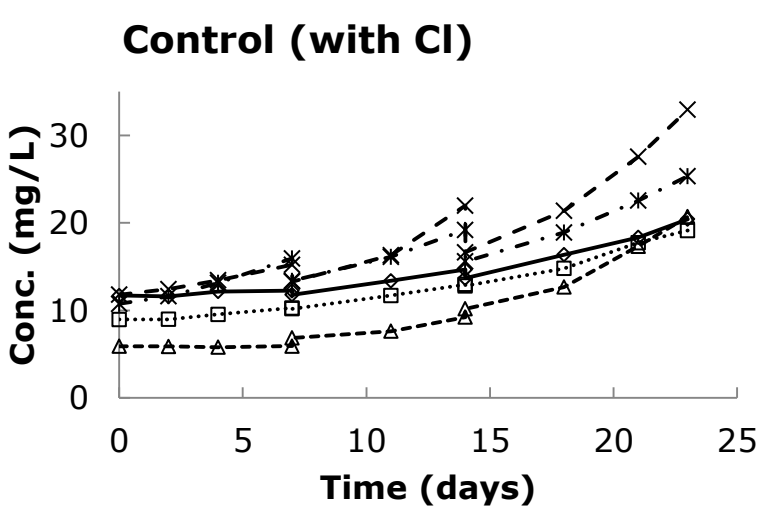


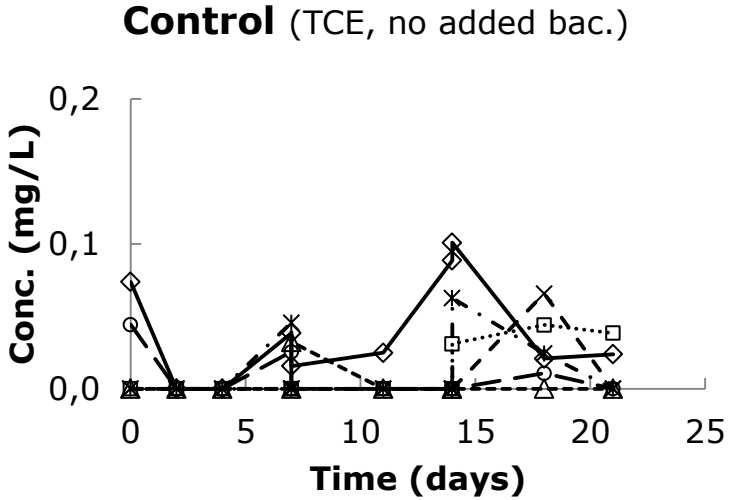


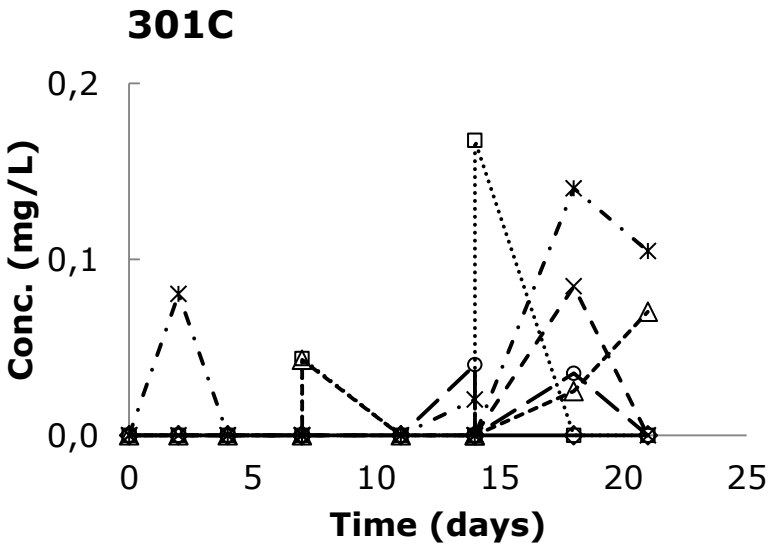


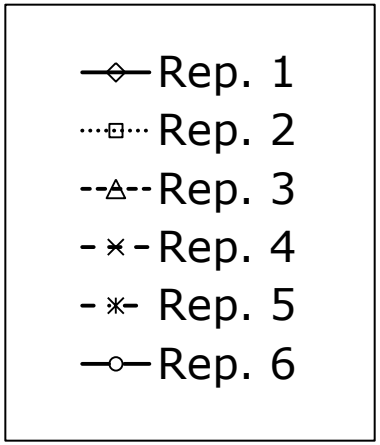


Cl in solution

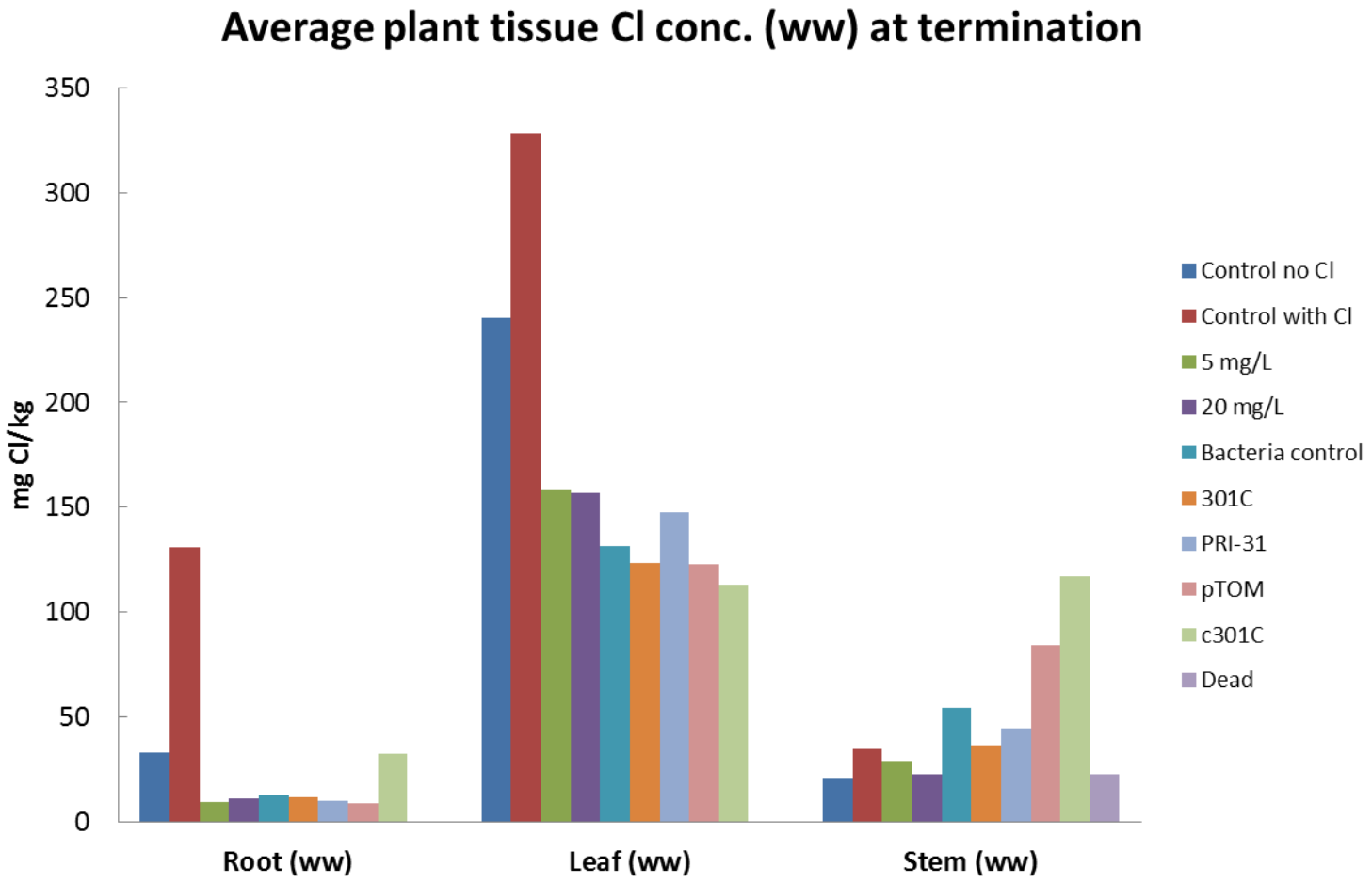








Cl in plant tissue



Cl mass

Mass of Cl (mg) added to the test-systems as TCE, total mass of Cl (mg) in the plants, Cl mass (mg) in solution, total Cl mass present and % distribution of Cl mass in the plant compartments: Root, Leaf and stem, at experiment termination.

Group	Cl added (mg)	Cl in plant (mg)	Cl in sol. (mg)	Tot. Cl (mg)
Control no Cl	0.0 (0.0)	1.9 (0.9)	0.0 (0.0)	1.9 (0.9)
Control with Cl	89.1 (5.7)	4.5 (0.9)	5.6 (1.2)	10.1 (2.1)
5 mg TCE/L	18.9 (6.5)	1.9 (0.9)	0.0 (0.0)	1.9 (0.9)
20 mg TCE/L	20.7 (5.2)	1.3 (0.3)	0.1 (0.1)	1.4 (0.4)
Dead	6.3 (0.7)	0.8 (0.2)	0.0 (0.0)	0.8 (0.2)
Control (TCE, no bac.)	20.9 (3.0)	2.4 (1.0)	0.0 (0.0)	2.4 (1.0)
301C	19.2 (3.4)	1.6 (0.7)	0.0 (0.0)	1.6 (0.7)
PR1-31	18.4 (1.4)	1.8 (1.1)	0.0 (0.0)	1.8 (1.1)
pTOM	17.0 (1.7)	2.5 (2.8)	0.0 (0.0)	2.5 (2.8)
301C, no TCE	0.0 (0.0)	4.9 (6.6)	0.0 (0.0)	4.9 (6.6)

Values are average of the replicates. Numbers in brackets indicate +/- 95% confidence intervals

TCE removal rates

First order removal rates (1/day)

Group	rate *k* (week 1)	rate *k* (week 2)	rate *k* (week 3)
5 mg TCE/L	0.77 (0.07)	0.62 (0.06)	0.56 (0.06)
20 mg TCE/L	0.70 (0.05)	0.63 (0.06)	0.55 (0.05)
Dead	0.65 (0.03)	-	-
Control (TCE, no bac.)	0.65 (0.06)	0.58 (0.04)	0.62 (0.06)
301C	0.61 (0.03)	0.58 (0.04)	0.60 (0.07)
PR1-31	0.66 (0.07)	0.60 (0.08)	0.64 (0.09)
pTOM	0.64 (0.05)	0.53 (0.03)	0.59 (0.05)

Values are average of the replicates. Numbers in brackets indicate +/- 95% confidence intervals.

Conclusion

1. Cl conc. in solution increases as the willows take up water

2. No or very little TCE was mineralized to Cl

3. We cannot see significant difference between the TCE removal rates k_{vol}, $k_{vol} + k_{tree}$ and $k_{vol} + k_{tree.} + k_{bac.}$

To do...

To improve the study use labelled TCE.

Analysis which will be done:

TCAA (samples stored at -80 ^{o}C)

Microbial community of the plant roots

Questions?

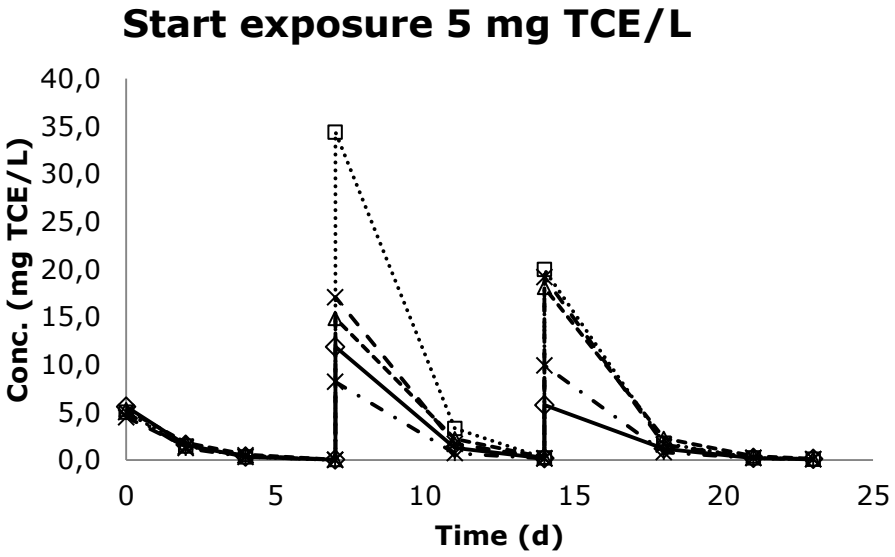
References

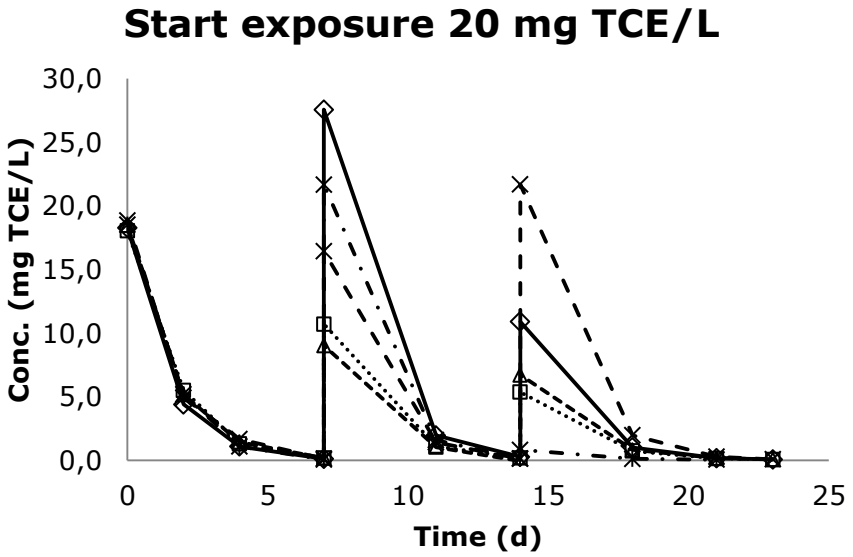
Department of Microbiology and Immunology (DMI), 2015, College of Medicine, University of Illinois; "Genes for 2,4,5- Trichlorophenoxyacetic Acid Metabolism in B. cepacia AC1100".

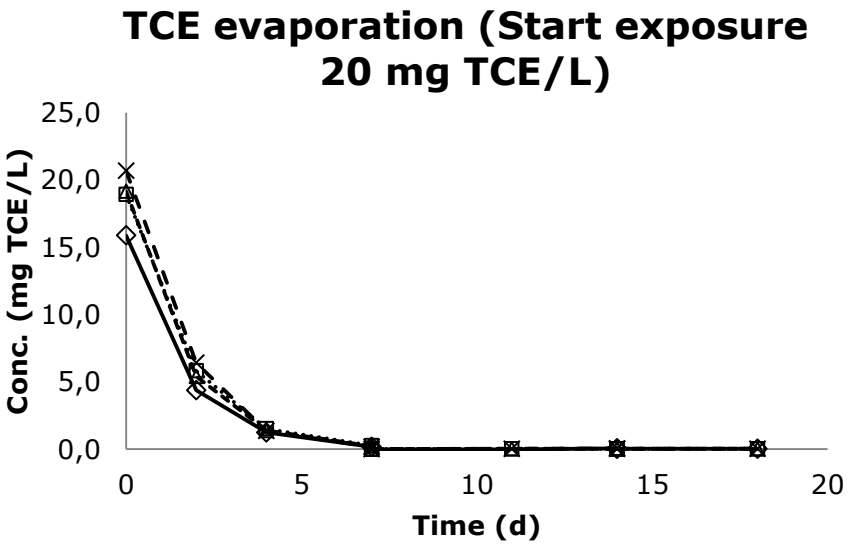
Folsom, B.R., Chapman, P.J. and Pritchard P.H., 1990, Phenol and trichloroethylene degradation by Pseudomonas cepacia G4: Kinetics and interactions between substrates. Appl. Environ. Microbiol.. 56 (5): 1279-1285.

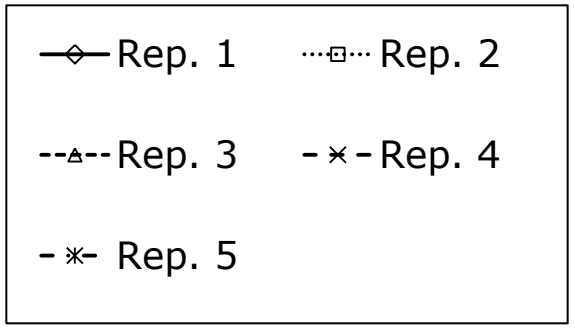
Public Health Image Library (PHIL), 2015, Center for disease control and prevention, link: http://phil.cdc.gov/phil/details.asp?pid=255 – accessed 15/09/2015

TCE in solution



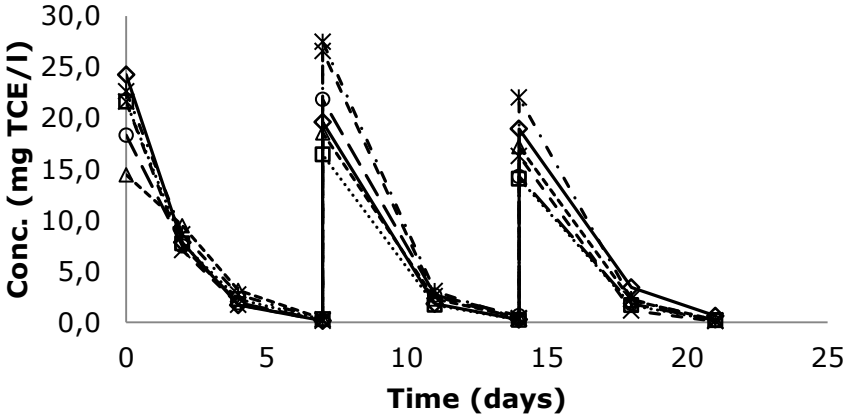




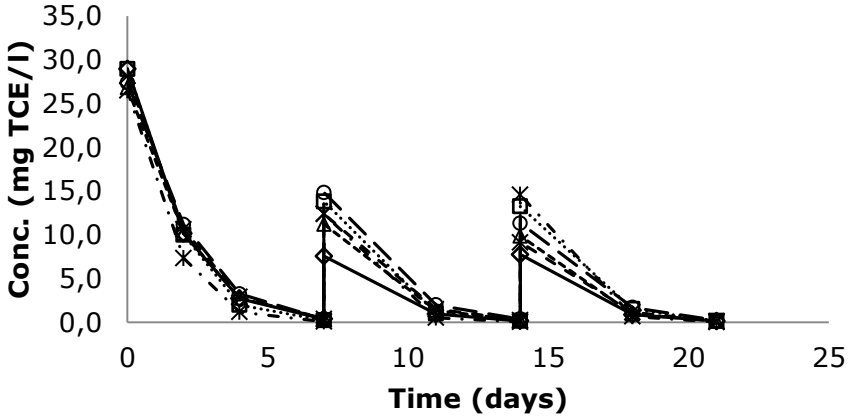


TCE in solution

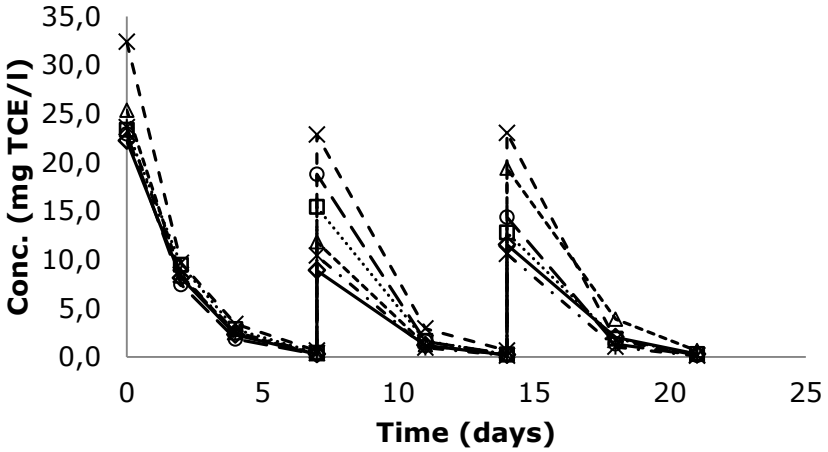
Control (TCE, no added bacteria)



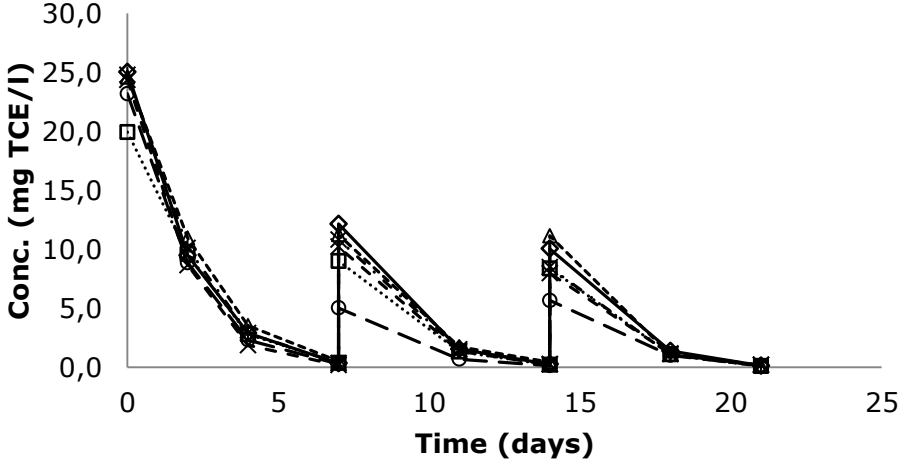
PRI-31



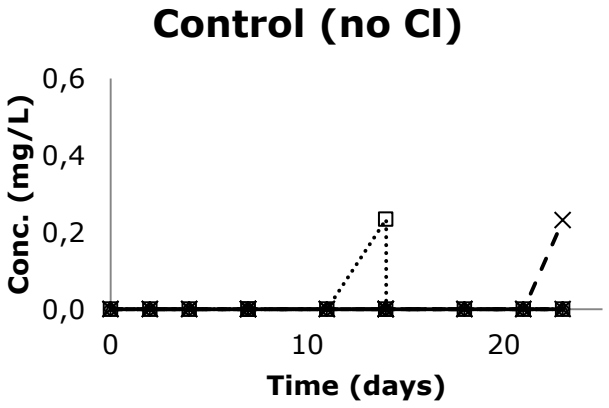
301C

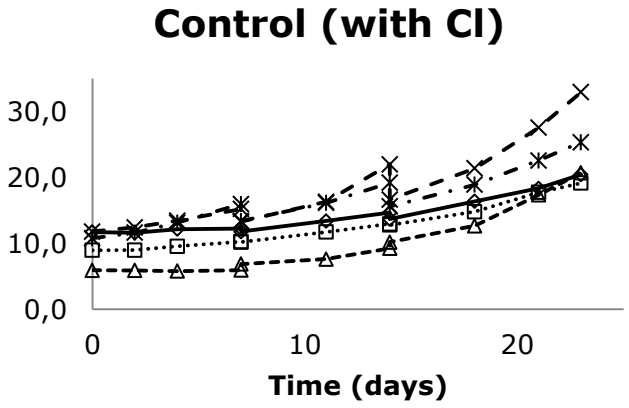


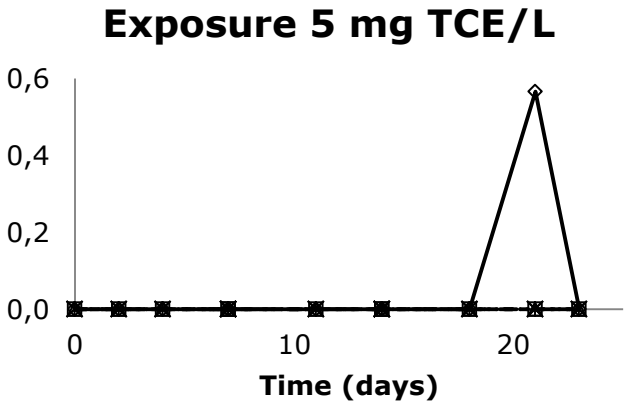
pTOM

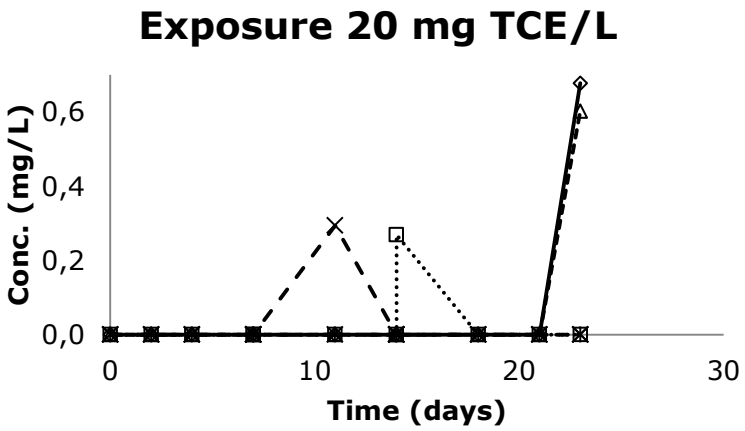


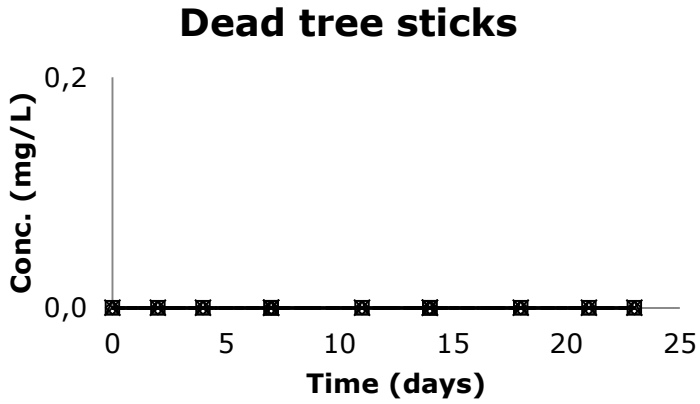
Cl in solution

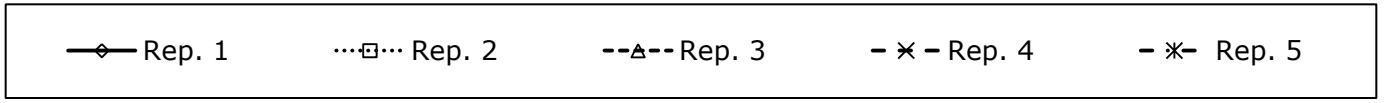






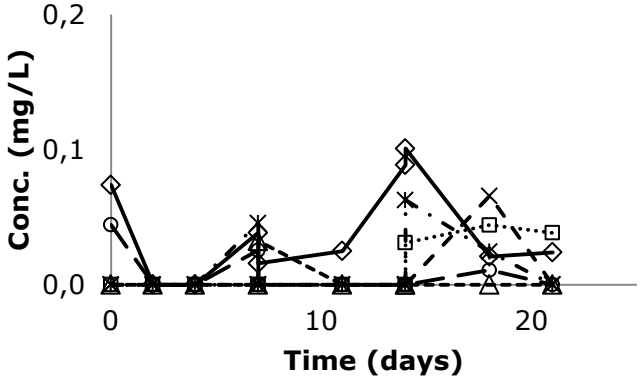






Cl in solution

Control (TCE, no added bac.)



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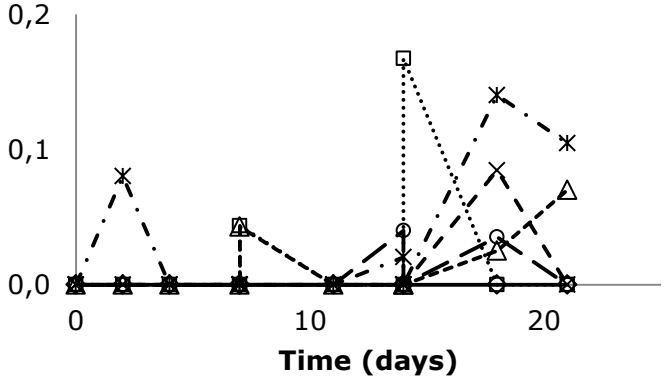
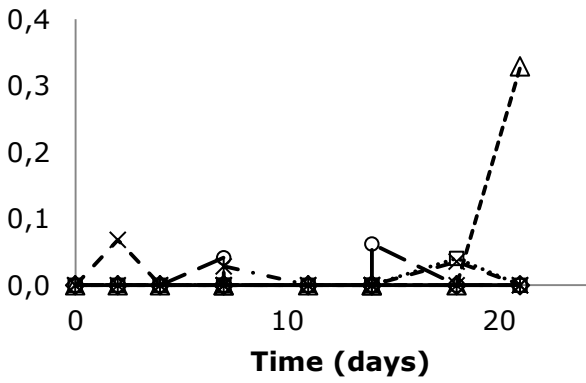
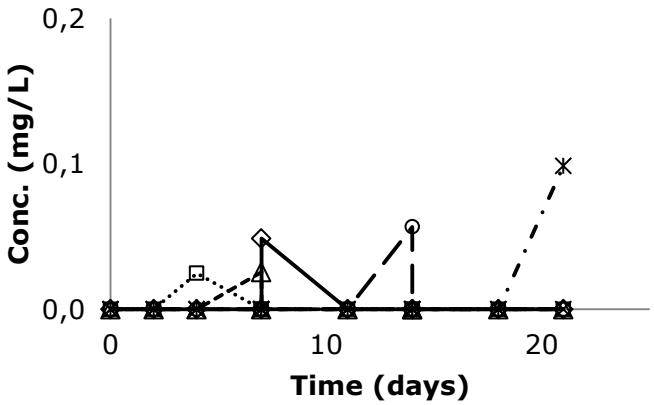


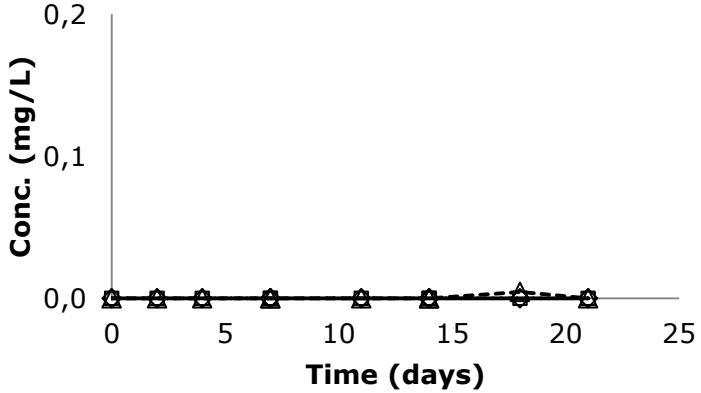
PRI-31



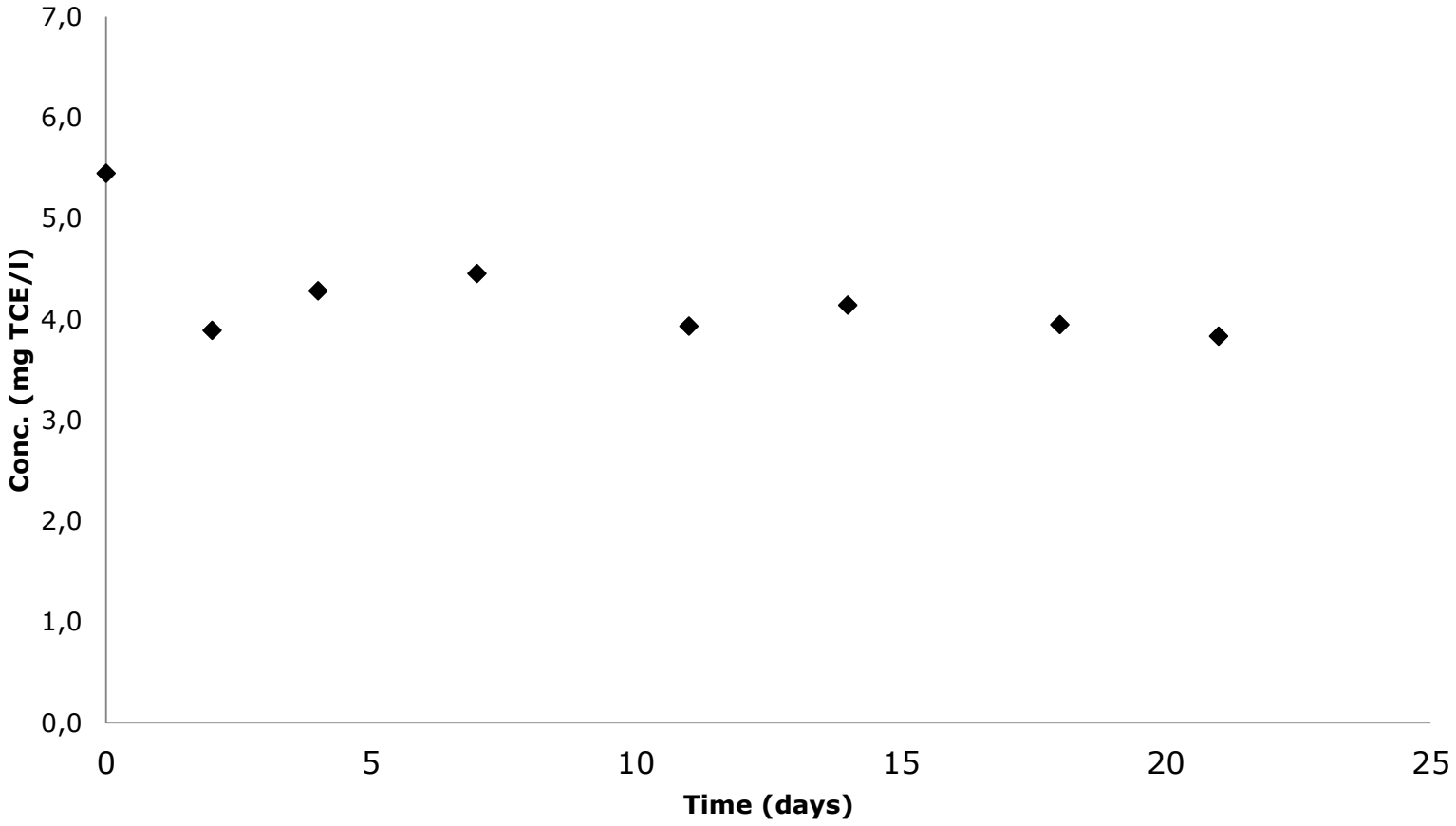
pTOM



301C (no TCE)



TCE in vials with 301C (no trees)



Cl in vials with 301C (no trees)